Renormalization for the self-potential of a charge in static space-times

Arkadiy Popov
Institute of Mathematics and Mechanics, Kazan Federal University, 18 Kremlyovskaya St., Kazan, 420008, Russia

The self-force is a force originating from the coupling between the charge of a particle and the field that this charge induces. The field induced by the point particle diverges at the particles location, and therefore a regularization method is required to calculate the correct (and finite) self-force from this diverging field. For this problem, formal expressions for the self-force have been derived for various types of fields. Some of them are reviewed in [1, 2]. Note also the zeta function method [3] and the massive field approach for the calculation of the self-force [4]. In the ultrastatic space-times the renormalization of the field of static charge can be realized by the subtraction of the first terms from DeWitt-Schwinger asymptotic expansion of a three-dimensional Euclidean Greens function [5, 6, 7, 8]. In this work a similar approach expands to the case of static space-times. In the framework of the suggested procedure one subtracts some terms of expansion of the corresponding Greens function of a massive scalar field with arbitrary coupling to the scalar curvature from the divergent expression obtained. The quantities of terms to be subtracted are defined by a simple rule – they no longer vanish as the fields mass goes to infinity. Such an approach is similar to renormalization introduced in the context of the quantum field theory in curved space-time [9, 10]. The Bunch and Parker method [11] is used for expansion of the corresponding Greens function of a scalar field.

We also implement this method to calculate analytically the scalar self-force on a particle, which is held static in the background of some wormhole spacetimes.

References

[1] W. Hikida, H. Nakano, M. Sasaki *Class. Quantum Grav.* **22** S753 (2005).

[2] L. Barack, *Class. Quantum Grav.* **26** 213001 (2009).

[3] C. O. Lousto, *Phys. Rev. Lett.* **84** 5251 (2000).

[4] E. Rosenthal, *Phys. Rev. D* **69** 064035 (2004).

[5] N. R. Khusnutdinov and I. V. Bakhmatov *Phys. Rev. D* **76** 124015 (2007).

[6] S. Krasnikov *Class. Quant. Grav.* **25** 245018 (2008).

[7] V. B. Bezerra and N. R. Khusnutdinov *Phys. Rev. D* **79** 064012 (2009).

[8] A. A. Popov *Phys. Lett. B* **693** 180 (2010).

[9] B. S. DeWitt, *Dynamical Theory of Groups and Field* (Gordon and Breach, New York, 1965).

[10] S. M. Christensen, *Phys. Rev. D* **17** 946 (1978).

[11] T. S. Bunch and L. Parker, *Phys. Rev. D* **20**, 2499 (1979).